

CLINICAL SCIENCE

Applying the new concept of maternal near-miss in an intensive care unit

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OBJECTIVES: The World Health Organization has recommended investigating near-misses as a benchmark practice for monitoring maternal healthcare and has standardized the criteria for diagnosis. We aimed to study maternal morbidity and mortality among women admitted to a general intensive care unit during pregnancy or in the postpartum period, using the new World Health Organization criteria.

METHODS: In a cross-sectional study, 158 cases of severe maternal morbidity were classified according to their outcomes: death, maternal near-miss, and potentially life-threatening conditions. The health indicators for obstetrical care were calculated. A bivariate analysis was performed using the Chi-square test with Yate's correction or Fisher's exact test. A multiple regression analysis was used to calculate the crude and adjusted odds ratios, together with their respective 95% confidence intervals.

RESULTS: Among the 158 admissions, 5 deaths, 43 cases of maternal near-miss, and 110 cases of potentially life-threatening conditions occurred. The near-miss rate was 4.4 cases per 1,000 live births. The near-miss/death ratio was 8.6 near-misses for each maternal death, and the overall mortality index was 10.4%. Hypertensive syndromes were the main cause of admission (67.7% of the cases, 107/158); however, hemorrhage, mainly due to uterine atony and ectopic pregnancy complications, was the main cause of maternal near-misses and deaths (17/43 cases of near-miss and 2/5 deaths).

CONCLUSIONS: Hypertension was the main cause of admission and of potentially life-threatening conditions; however, hemorrhage was the main cause of maternal near-misses and deaths at this institution, suggesting that delays may occur in implementing appropriate obstetrical care.

KEYWORDS: Maternal mortality; Maternal near-miss; Organ dysfunction or failure; Obstetrical hemorrhage; Severe pre-eclampsia/eclampsia.

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INTRODUCTION

Traditionally, maternal mortality is considered to be an indicator of economic development and of the quality of obstetrical care. A 75% reduction in maternal mortality by 2015 is one of the Millennium Development Goals (1). In Brazil, the true magnitude of maternal mortality remains unknown, with estimates ranging from 38 to 87 deaths per 100,000 live births (2,3). These differences are due to variations in the techniques used to obtain the maternal mortality data and other factors, such as the incomplete coverage provided by the mortality information system (4) across the country and the frequent absence of the causes of

maternal deaths from the official death registers, as shown in several studies that have evaluated deaths in women of reproductive age (4-7).

The search for a new indicator of the quality of obstetrical care has motivated investigators, initially in developed countries, to investigate hospital obstetrical morbidity; due to the small number of cases, surveys of maternal mortality alone are less and less useful for improving maternal health in general (8). These studies have revealed that maternal mortality represents the tip of an iceberg; for each death, many other women survive serious complications during pregnancy, delivery, and the puerperium that lead to different degrees of sequelae. In the majority of cases, these complications are consequences of the same factors that cause death (9). Investigating this group of women will increase understanding of the failures of obstetrical care within the healthcare systems of developing countries (10).

Different classifications, such as severe maternal morbidity (SMM), obstetrical morbidity, and maternal near-miss, have already been used to describe the severe complications

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that occur during pregnancy and delivery and in the puerperium. The term "near-miss" describes a serious adverse event that only failed to occur by luck or by adequate management (11). This concept was recently defined by the World Health Organization (WHO) as "a woman who, being close to death, survives a complication that occurred during pregnancy, delivery or up to 42 days after the end of her pregnancy" (10).

The WHO has recommended investigating near-misses as a benchmark practice for monitoring maternal healthcare and has standardized the criteria for diagnosis. The criteria emphasize the presence of organ dysfunction or failure that is identified using three groups of criteria (clinical, laboratory, and management). Complications in pregnancy, childbirth and the puerperium were classified by increasing severity into potentially life-threatening conditions (PLTC) and life-threatening conditions (LTC) (near-misses and near-misses that progressed to maternal death). The WHO also defined indicators of obstetrical care based on near-misses and maternal deaths (10).

In Brazil, the systematic investigation of maternal near-misses in the different institutions that provide obstetrical care may prove useful for reducing maternal mortality; as shown by the National Survey on Women and Children's Demographics and Healthcare (PNDS), 98% of Brazilian births occur in hospital environments (12). Therefore, the objective of the current study was to use the new WHO near-miss criteria to investigate maternal morbidity and mortality in a population of women with complications associated with pregnancy, childbirth or the postpartum period.

METHODS

Hospital and country setting. This study was conducted at a hospital in the city of Limeira, which is situated in the eastern region of the state of São Paulo, Brazil; this city has an estimated population of 281,000 inhabitants and 3,697 live births in 2008. The hospital is a general teaching facility that serves as a referral center for a catchment area with a population of approximately 1.4 million inhabitants. It has 287 beds, of which 18 are in the adult intensive care unit (ICU), 8 are in the neonatal ICU, 18 are in semi-intensive care, and 37 are in the maternity wing, where approximately 2,200 deliveries are performed annually.

Case definitions. We used an operational definition of severe maternal morbidity (SMM) for all of the cases admitted to the ICU; this definition combined all of the LTC and PLTC, as presented in the original article (10). The primary determinants of SMM (i.e., the clinical diagnoses of severe morbidity at admission) were classified as obstetrical (hypertensive, hemorrhagic, infectious, or others) and non-obstetrical or clinical/surgical for morbidities resulting from another cause but manifesting during pregnancy. The WHO criteria were used to identify maternal near-misses (10).

Case findings

This is a cross-sectional study of women who were admitted to an ICU during pregnancy or childbirth or in the postpartum period between January 1st, 2004 and December 31st, 2007. One of the investigators was responsible for the identification and collection of data from the medical charts of the women and newborn infants, using a specific form for this purpose. The total number of deliveries and

newborn infants was supplied by the institution's medical archives service. Following the WHO definitions, the final outcomes of the women were grouped into potentially life-threatening conditions (i.e., severe clinical or obstetrical conditions without any organ dysfunction) or LTC (i.e., cases of maternal mortality and near-miss) (10). The study assessed sociodemographic characteristics (age, marital status, and category of admission), obstetrical history (parity and type of previous delivery), history of morbidities, factors associated with the current pregnancy (outcome of pregnancy, gestational age at delivery, number of prenatal visits and city of origin), maternal outcomes (duration of ICU stay, total duration of hospitalization and life support procedures and/or interventions) and perinatal outcomes (stillbirth, Apgar score, gestational age at birth, weight, whether the neonate had to be admitted to an ICU, condition at discharge from hospital, and perinatal mortality).

Analysis. We first identified the criteria for maternal near miss, so we could classify the women into potentially life-threatening conditions, near-misses, and deaths. The indicators of obstetrical care were calculated using the ratios of maternal mortality, near-miss, PLTC and LTC (maternal mortality plus the number of cases of near-miss) to the number of live births; the near-miss/maternal mortality ratio and the mortality index were also used. Bivariate analyses using the Chi-squared test with Yate's correction or Fisher's exact test were performed for the characteristics potentially associated with ICU admission. A multiple regression analysis was used to calculate crude and adjusted odds ratios (ORs), together with their respective 95% confidence intervals (95% CIs).

Ethical considerations. The project was conducted in compliance with the regulations established by the National Health Council (Resolution CNS 196/96) and was approved by the Institutional Review Board (CPE/ISCML 134/08).

RESULTS

During the four years of the study, 158 cases of SMM were admitted to the ICU, the maternity registered 9,683 live births, the rate of admission to an ICU was 1.6% of all deliveries, the mortality rate was 3.1% of admissions (five deaths) and 43 of the 158 cases of severe maternal morbidity (27.2%) met the criteria for a diagnosis of near-miss.

The mean age of the women was 28 ± 7 years (range 13-44 years), the mean gestational age was 33 ± 6 weeks (range 8-41 weeks), 45.4% were primigravida, and the majority were admitted to the ICU following delivery (138/158 cases, 87.3%). The mean ICU stay was 3 ± 5 days (range 0-44 days), and 85.8% of the deliveries were performed by Caesarean section (121/141 deliveries). A total of 78 (60%) newborn infants required admission to the neonatal ICU; of these infants, 73 infants (93.5%) were later discharged from hospital. The woman was older than 30 years of age in four of the five cases maternal mortality, and the mean gestational age was 37 ± 2.6 weeks. Dysfunction or failure of the cardiovascular, respiratory, renal, hepatic, hematological, and/or central nervous systems was associated with all of the cases of near-miss and maternal mortality (data not shown).

Table 1 shows the diagnoses of near miss grouped according to the WHO's clinical, laboratory, and management criteria. The presence of shock, $\text{PaO}_2/\text{FiO}_2 < 2000$ mmHg and continuous use of vasoactive drugs and hysterectomy were

Table 1 - The distribution of maternal near-misses using the WHO criteria.

WHO criteria	Death + Near-Miss	
	n (48)	%
Clinical Criteria		
Shock	7	14.6
Oliguria unresponsive to fluids or diuretics	4	8.3
Loss of consciousness ≥12 h	5	10.4
Jaundice with pre-eclampsia	1	2.1
Repeated seizures	1	2.1
Laboratory Criteria		
Oxygen saturation <90% at ≥60 min	1	2.1
PaO ₂ /FiO ₂ <200 mmHg	8	16.7
Creatinine ≥3.5 mg/dl	2	4.2
Total bilirubin ≥6.0 mg/dl	3	6.3
Acute thrombocytopenia (<50,000 platelets)	7	14.6
Management Criteria		
Continuous use of vasoactive drugs	20	41.7
Hysterectomy due to infection or bleeding	20	41.7
Transfusion of red blood cell concentrates ≥5 units	19	39.6
Intubation and mechanical ventilation for ≥60 minutes	13	27.1
Cardiopulmonary resuscitation	5	10.4

Acute cyanosis, gasping, respiratory rate >40 or <6/min, positive bedside coagulation test, loss of consciousness and absence of pulse/heart beat were not found.

Lactate >5 mg/dl was not measured for ICUs.

the most prevalent clinical, laboratory, and management criteria, respectively.

Obstetrical complications were responsible for more than 80% of the ICU admissions in cases of PLTC;

hypertensive conditions were the most common form of complication (67.7%). In cases of near-miss or death, by contrast, the main factors involved were hemorrhagic complications in 39.5% of cases (17/43) and 40% of cases (2/5), respectively. Infections were reported in 17 cases, corresponding to an incidence of 1.75 per 1,000 live births and were classified as obstetrical in 3 cases and non-obstetrical in 14 cases (Table 2).

The maternal mortality ratio (MMR) for the institution was 51.6 per 100,000 live births, the maternal near-miss ratio (MNMR) was 4.4 per 1,000 live births and the morbidity/mortality ratio (MNMR: MMR) was 8.6 cases for every death. The overall mortality index was 10.4% (Table 3).

As shown in Table 4, the only factor in the multiple regression analysis that was associated with a lower occurrence of near-miss/maternal death among the women with severe maternal morbidity was delivery by Caesarean section.

The total hospitalization time, the total time in the ICU, and the numbers of interventions and life support procedures, such as blood transfusions, were greater in the cases of near-miss and death. Among the cases of near-miss and death, 20 peripartum hysterectomies occurred (42%). A high prevalence of preterm deliveries in the overall SMM group and a significantly higher incidence of stillbirths in the women who died or experienced a near-miss can be seen in Table 5; however, there were no statistically significant differences with respect to perinatal mortality.

DISCUSSION

Our current results represent a hospital-based investigation of maternal near miss, as recommended by the WHO (10). The criteria we used were based on the presence of

Table 2 - The distribution of the primary determinants of severe maternal morbidity according to the ICU admission outcomes.

Primary determinants of severe maternal morbidity	Death		Near-Miss		PLTC		Total	
	n (5)	%	n (43)	%	n (110)	%	n (158)	%
Hypertension	-	-	14	32.6	93	84.5	107	67.7
Eclampsia	-	-	4	9.3	23	20.9	27	17.1
Severe pre-eclampsia	-	-	5	11.6	59	53.6	64	40.5
HELLP	-	-	5	11.6	10	9.1	15	9.5
APO	-	-	-	-	1	0.9	1	0.6
Hemorrhages	2	40.0	17	39.5	1	0.9	20	12.7
Premature separation of placenta	-	-	3	7.0	-	-	3	1.9
Ectopic	-	-	5	11.6	-	-	5	3.2
Uterine rupture	1	20.0	-	-	-	-	1	0.6
Placenta accreta	-	-	1	2.3	-	-	1	0.6
Atony	1	20.0	8	18.6	1	0.9	10	6.3
Infections	1	20.0	1	2.3	1	0.9	3	1.9
Chorioamnionitis	-	-	-	-	1	0.9	1	0.6
Endometritis	1	20.0	1	2.3	-	-	2	1.3
Others	-	-	-	-	2	1.8	2	1.3
Hyperemesis	-	-	-	-	2	1.8	2	1.3
Clinical/Surgical	2	40.0	11	25.6	13	11.8	26	16.5
Pneumonia	1	20.0	6	14.0	3	2.7	10	6.3
Tuberculosis	-	-	1	2.3	-	-	1	0.6
Cardiac pathologies	-	-	-	-	4	3.6	4	2.5
Ketoacidosis	-	-	1	2.3	2	1.8	3	1.9
Pyelonephritis	-	-	2	4.7	2	1.8	4	2.5
Anaphylactic reaction	-	-	-	-	1	0.9	1	0.6
Pancreatic neoplasia	1	20.0	-	-	-	-	1	0.6
Epilepsy	-	-	1	2.3	-	-	1	0.6
Exogenous intoxication	-	-	-	-	1	0.9	1	0.6
Total	5	100.0	43	100.0	110	100.0	158	100.0

Table 3 - The indicators of obstetric care according to the primary determinants of ICU admission outcomes.

Primary determinants	Death	Near Miss	PLTC	MMR	MNMR	PLTCR	SMOR	MNMR: MMR	MI (%)
Hypertension	-	14	93	-	1.4	9.6	1.4	-	-
Hemorrhages	2	17	1	20.6	1.7	0.1	1.9	8.5:1	10.5
Infections	1	1	1	10.3	0.1	0.1	0.2	1:1	50.0
Others	-	-	2	-	-	0.2	-	-	-
Clinical/surgical	2	11	13	20.6	1.1	1.3	1.3	5.5:1	15.3
Total	5	43	110	51.6	4.4	11.3	4.9	8.6:1	10.4

Live births: 9,683.

Maternal mortality ratio (MMR): number of deaths/number of live born infants × 100,000.

Maternal near-miss ratio (MNMR): number of cases of near-miss/number of live births ×1,000.

Potentially life-threatening conditions (PLTC) ratio: number of PLTC/number of live births ×1,000.

Severe maternal outcome ratio (SMOR): number of life-threatening conditions (death + near-miss)/number of live births ×1,000.

Maternal near-miss ratio: maternal death ratio (MNMR:MMR).

Mortality index (MI): number of deaths/number of deaths + number of near-miss ×100 (%).

organic dysfunction or failure, which have been identified by several authors as the best markers for maternal near-miss (13-15). The different criteria for maternal near-miss (clinical, laboratory, and management) generally represent different levels of system or organ dysfunction and/or failure. In this study, we found no difficulties in using and identifying these criteria, with the exception of certain clinical criteria, such as gasping, cyanosis and bedside clotting tests, which normally occur before the complex care received in an ICU.

We support keeping PLTC as the initial classification in the continuum of maternal severe morbidity, near-miss and death. We also believe that grouping them using the same direct obstetrical causes of maternal death can be useful for distinguishing the cases from their primary determinants, which will then evolve to near-miss or death. Near-miss cases share many characteristics with maternal deaths and can provide direct information about the obstacles that had to be overcome after the onset of an acute complication; hence, they provide valuable information on obstetrical care.

In our study, the main primary determinant of severe maternal morbidity was hypertensive disorders, including a high prevalence of eclampsia (27 cases or 25.2% of the cases

of hypertension). Despite the high number of cases, which may suggest delays in preventing seizures, progression to near-miss occurred in only four cases, and no cases resulted in death. The favorable outcomes in the majority of cases would appear to justify the exclusion of eclampsia, a clinical diagnosis, from the near-miss criteria recently established by the WHO. The lack of death from severe pre-eclampsia/eclampsia may be attributed to better intrahospital care and appropriate interventions within an adequate timeframe, such as magnesium sulfate and timely interruption of the pregnancy.

Hemorrhagic complications (mainly postpartum bleeding, uterine atony, and uterine rupture) had great potential for leading to near miss and death, accounting for 39.5% and 40% of the cases, respectively. Of the cases of near-miss due to hemorrhage, the most important cause is uterine atony (8/17 cases). This finding is consistent with the increasing trend currently found in developed countries (16-18). In a population-based study of all the hospitals in Canada (17), the rate of any degree of postpartum uterine atony increased from 29.4 per 1,000 deliveries in 1991 to 39.5 per 1,000 deliveries in 2004, with no significant change in the other causes of postpartum hemorrhage. Despite the existence of standardized protocols for managing hemorrhage, it is

Table 4 - The estimated risk of maternal morbidity according to maternal characteristics, history of morbidities, obstetrical history and care during pregnancy.

Characteristics	Death + Near-miss N (5) %		PLTC N (110) %		p-value	OR (95%CI)	OR _{adj} (95%CI)
Age > 34 years	14	29.1	20	18.1	0.18	1.85 (0.78-4.37)	9.00 (0.86-94.33)
SUS category of admission to ICU	41	85.4	88	80	0.55	1.46 (0.54-4.12)	0.99 (0.10-10.11)
Marital status – no fixed partner #	5	11.1	23	21.1	0.21	0.47 (0.14-1.43)	3.07 (0.20-46.65)
Comorbidities present ##	17	39.5	62	60.1	0.03	0.43 (0.20-0.95)	0.33 (0.05-2.32)
Multiparity *	9	19.5	8	7.4	0.05	3.04 (0.98-9.49)	0.35 (0.02-5.07)
Previous Caesarean section *	10	38.4	28	48.2	0.54	0.67 (0.23-1.9)	0.25 (0.03-2.27)
Previous normal delivery*	21	80.7	25	43.1	0.00	5.54 (1.66-19.63)	0.45 (0.04-1.91)
Transferred from city of origin	11	22.9	41	37.2	0.11	0.5 (0.2-1.15)	0.26 (0.04-1.91)
Gestational age ≤36 weeks **	27	64.2	73	66.3	0.95	0.91 (0.41-2.05)	2.47 (0.31-19.39)
< 6 prenatal consultations ***	11	28.2	45	46.3	0.07	0.45 (0.19-1.08)	4.44 (0.67-29.53)
Pregnancy delivered by Caesarean section	29	72.5	92	91	0.01	0.26 (0.09-0.75)	0.03 (0.002-0.49)

Chi-squared test with Yates correction.

Data missing in 3 cases of maternal near-miss (MNM) and death and in 1 case of PLTC.

Data missing in 5 cases of MNM and death and in 7 cases of PLTC.

*Data missing in 2 cases of MNM and death and in 2 cases of PLTC.

**Data missing in 6 cases of MNM and death.

***Data missing in 19 cases of MNM and death and in 13 cases of PLTC.

Table 5 - The maternal and perinatal results according to the maternal ICU admission outcomes.

Results	Death + Near-Miss		PLTC		p-value	OR (95%CI)
	N (48)	%	N (110)	%		
Maternal results						
Pregnancy outcome						
Vaginal delivery	11	27.5	9	8.9	-	1 (ref)
Caesarean section	29	72.5	92	91.0	0.0097a	0.26 (0.09-0.75)
Ectopic pregnancy	5	-	-	-	-	-
Still pregnant	3	-	9	-	-	-
Admission to the ICU following delivery	41	85.4	97	88.1	0.8253a	0.78 (0.27-2.36)
Time in ICU > 2 days	27	56.2	26	23.6	0.0001a	4.15 (1.91-9.12)
Hospitalization > 7 days	28	58.3	40	36.3	0.0168a	2.45 (1.16-5.2)
Blood transfusion	38	79.1	32	30.0	<0.0001a	8.87 (3.7-21.65)
Vasoactive drugs**	20	41.6	-	-	-	-
Hysterectomy **	20	41.6	-	-	-	-
Intubation and ventilation**	13	27.0	-	-	-	-
Cardiopulmonary resuscitation **	5	10.41	-	-	-	-
Perinatal						
Gestational age < 37 weeks	15	31.2	58	52.7	0.0205a	0.41 (0.19-0.88)
1 st minute Apgar < 7 *	8	25	30	29.7	0.773b	0.79 (0.29-2.11)
5 th minute Apgar < 7 *	-	-	3	3	0.4218b	-
Weight < 2,500 g *	16	48.4	49	50.5	1.0000a	0.92 (0.39-2.18)
Admission to neonatal ICU	17	51.5	61	62.8	0.3440a	0.63 (0.26-1.50)
Neonatal outcome						
Discharged	17	100	56	91.8	-	1 (ref)
Died	-	-	4	6.5	0.3603b	-
Stillborn	7	17.5	4	3.9	0.0122b	5.14 (1.24-22.6)
Perinatal death	7	21.2	8	8.2	0.0786b	2.57 (0.77-8.61)

a: Chi-squared test with Yates correction.

b: Fisher's exact test.

*Data missing for 1 case of MNM + death.

**Diagnostic criterion for maternal near-miss.

interesting to note the high incidence of blood transfusions and, particularly, of peripartum hysterectomy, which was performed in 33% of cases of near-miss or death (a rate of 1.65 cases per 1,000 births). In the United States (19), a population-based study found a significant increase in the rate of peripartum hysterectomy resulting from hemorrhage. The rate increased from 0.25 per 1,000 deliveries in 1987 to 0.82 per 1,000 in 2006, principally due to uterine rupture, placental retention and uterine atony.

The total number of near-miss cases resulting from infectious causes (both obstetric and non obstetric) was 0.9 per 1,000 live births, well above the developed countries rate (20,21) of 0.2 per 1,000 live births. The near miss/maternal death ratio for infection was 4.5 cases for each death, and the mortality index was 18%.

When analyzing the women for whom morbidity was associated with a progression to PLTC, near-miss or death, only Caesarean section was a statistically significant protective factor. The rate of interrupting a high-risk pregnancy by performing a Caesarean section is admittedly high; however, it was used in 86% of cases in this study. The high incidence of this procedure may represent a selection bias. Nevertheless, it is important to remember that in situations such as those situations found in the present study, a Caesarean section may be interpreted either as a solution for cases of morbidity or as a determining factor of morbidity.

The high rate of preterm delivery found in the group with PLTC may have been affected by the greater number of admissions due to severe pre-eclampsia/eclampsia, a situation in which premature interruption of pregnancy is more common (22).

Because of its retrospective design and because it was performed in a single institution, the present study has some limitations. In addition, some important data were inconsistent or were filled out correctly on the patient charts, for example, evaluations of the delays in managing the cases at different levels within the healthcare system. However, the study is innovative in the sense that it applies the new WHO criteria for near-miss and uses indicators that may be helpful for monitoring the quality of obstetric care. A prospective surveillance study involving 27 centers in Brazil and using these same criteria is currently underway; however, its results are not yet available (23).

Hypertension was the main cause of ICU admission and the main PLTC; however, hemorrhage was the primary determinant of maternal near-miss and death at this institution, suggesting that delays may occur in implementing appropriate obstetric care.

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AUTHOR CONTRIBUTIONS

Lotufo FA wrote the study protocol, created and implemented the analysis plan and was responsible for the first manuscript draft. Parpinelli MA had the original idea for the study, wrote the study protocol, created and implemented the analysis plan and was responsible for the first manuscript draft. Cecatti JG created and implemented the analysis plan. All the

authors provided important insights to the final version of the manuscript, participated in the results discussions, tables design, and read and approved the final version of the manuscript.

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